

A 41.5 Mc/s TRANSISTOR FIELD STRENGTH MONITORING RECEIVER

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SUMMARY

This report describes a simple field strength recording receiver designed for monitoring television sound transmissions at comparatively short distances from the transmitter. The main characteristics of the receiver are a good gain stability, small size and low power consumption. The receiver has been designed for use at 41.5 Mc/s but receivers of similar design will be built for the other sound channels.

1. INTRODUCTION

When carrying out a field strength survey of a television station it is customary to measure the field strength of the sound transmitter as the output of the vision transmitter varies appreciably with picture content. It is also advantageous to monitor the radiated field from a transmitter whilst other field strength records are being obtained. A receiver for this purpose should have very stable gain and frequency and be capable of operation in high fields. Measurements of low or very variable fields are not required and, since the required field is high, spurious responses will not normally give any trouble. As the receiver will frequently be installed in temporary accommodation it is an advantage for both the receiver and recorder to be small and light. An Evershed and Vignoles miniature recorder, weighing 9lb (4 kg), was chosen as the recording instrument and the receiver was made to fit into a similar sized case. Both the recorder and the receiver are mains operated. The necessary long-term frequency stability for the receiver is obtained from a crystal controlled local oscillator. A bandwidth of ± 40 kc/s at -1 dB is used to accommodate offset carriers. The receiver will measure fields of 1-200 mV/m F.S.D. when used with a $\lambda/2$ dipole and a short feeder. In order to obtain the low consumption and high gain stability with simple circuits, transistor amplifiers are used throughout the receiver. The gain is stable to within $\pm \frac{1}{2}$ dB over a wide range of temperature and supply voltage. A loudspeaker is provided for programme identification. The intermediate frequency was chosen to be as high as practicable using OC44 i.f. amplifiers whilst avoiding frequencies liable to give trouble from spurious responses when used on any Band I channel.

2 SPECIFICATION

Aerial input:	75 ohms unbalanced
Frequency:	41.5 Mc/s, crystal controlled
Bandwidth (see Fig. 1):	± 40 kc/s at -1 dB ± 60 kc/s at -3 dB ± 900 kc/s at -60 dB
Intermediate frequency:	3.75 Mc/s. Local oscillator low
Spurious responses:	< -26 dB
Local oscillator radiation:	Available power at aerial terminal < 10^{-10} watts
Sensitivity:	Using $\lambda/2$ dipole and short feeder 1-200 mV/m F.S.D. (8 ranges)
Response of detector:	Linear with approximately 20 dB range on meter
Recorder output:	1 mA into 3000 ohms, positive pole earthed
Loudspeaker fitted for programme identification	
Power supplies:	180-260 V 50 c/s
Power consumption:	7 VA at 230 V input
Gain stability (see Fig. 1):	$\pm \frac{1}{2}$ dB at 0-45°C ambient temperature 180-260 V a.c. input
Recorder output zero stability:	$\pm 2 \mu A$ at 0-45°C and 180-260 V a.c. input
I.F. response temperature drift:	< 5 kc/s at 0-45°C

3. CIRCUIT DESCRIPTION

The circuit diagram is shown in Fig. 2.

3.1. R.F. and Mixer Circuits

The aerial input to the receiver is through a switched attenuator with a maximum ratio of 200:1. The tuned r.f. circuit is magnetically coupled to a balanced crystal mixer MR1, MR2 the output of which feeds the i.f. amplifier. A balanced crystal mixer is used in order to keep the local oscillator coupling to the aerial at a very low level. A 12.583 Mc/s crystal controlled Pierce oscillator is biased so that sufficient third harmonic is available from a double tuned coupling circuit L1, C3, C5, L2, C6 in the emitter to give the local oscillator drive to the mixer. The mixer is drive biased by R32, and is adjusted for optimum working conditions.

3.2. I.F. Amplifier

The i.f. amplifier consists of four similar stages, VT2-VT5, of amplification. Grounded base stages employing bridge neutralization C14, R36, etc., are used with step-down transformers between stages. The emitter currents are kept constant by the

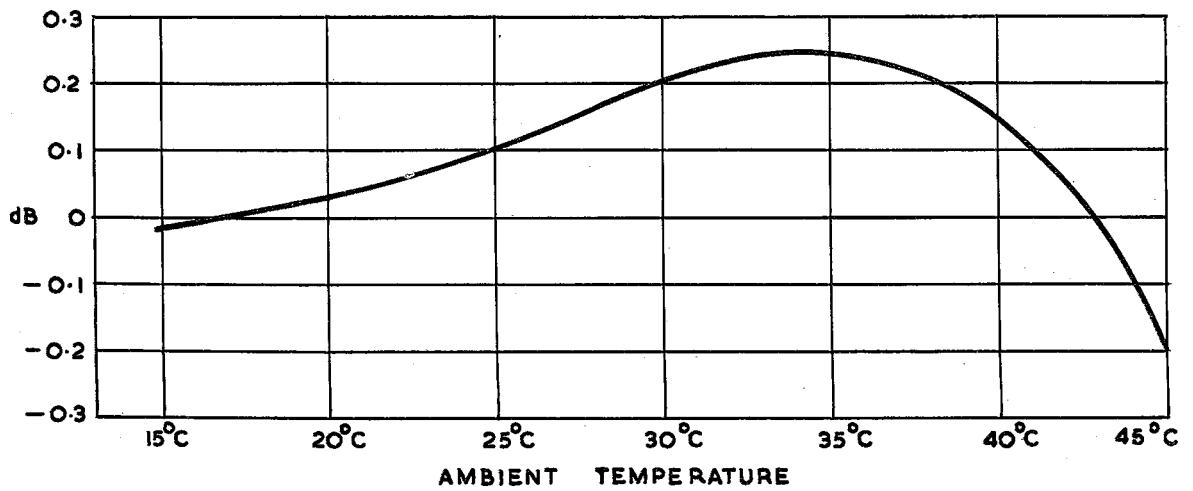
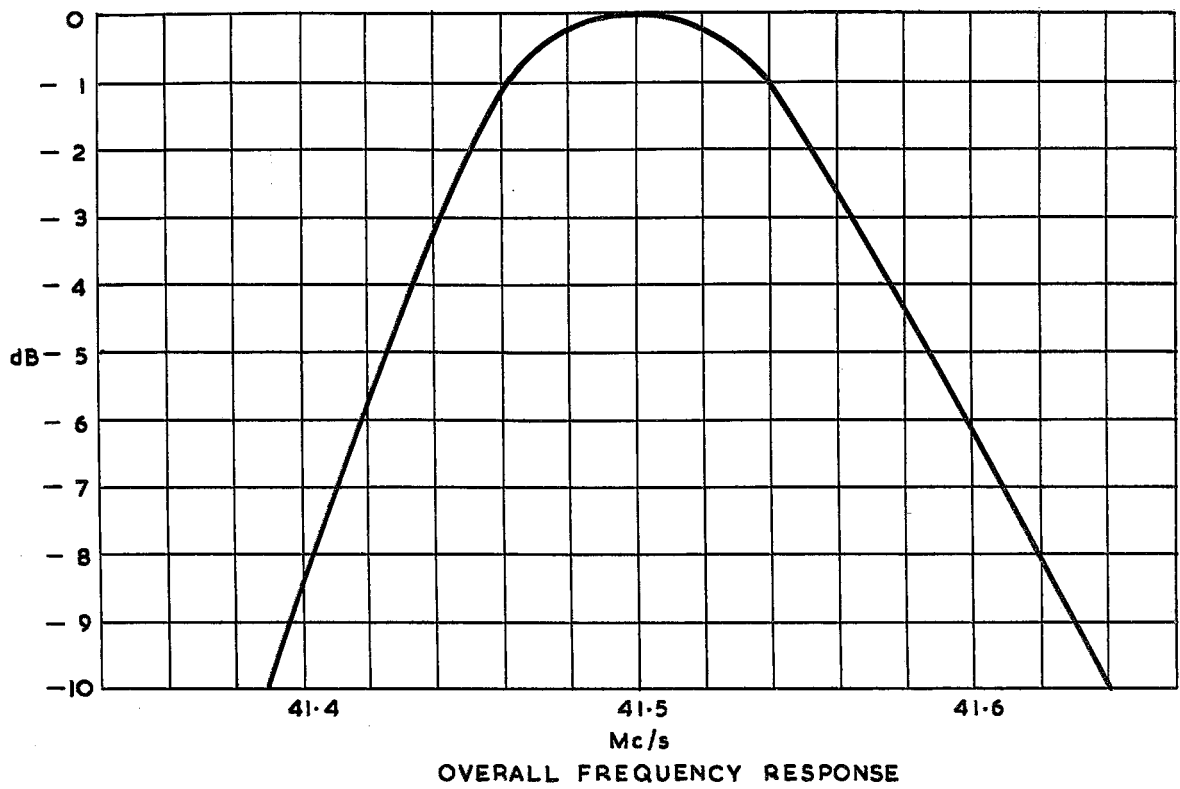


Fig. 1 - Bandwidth and gain stability

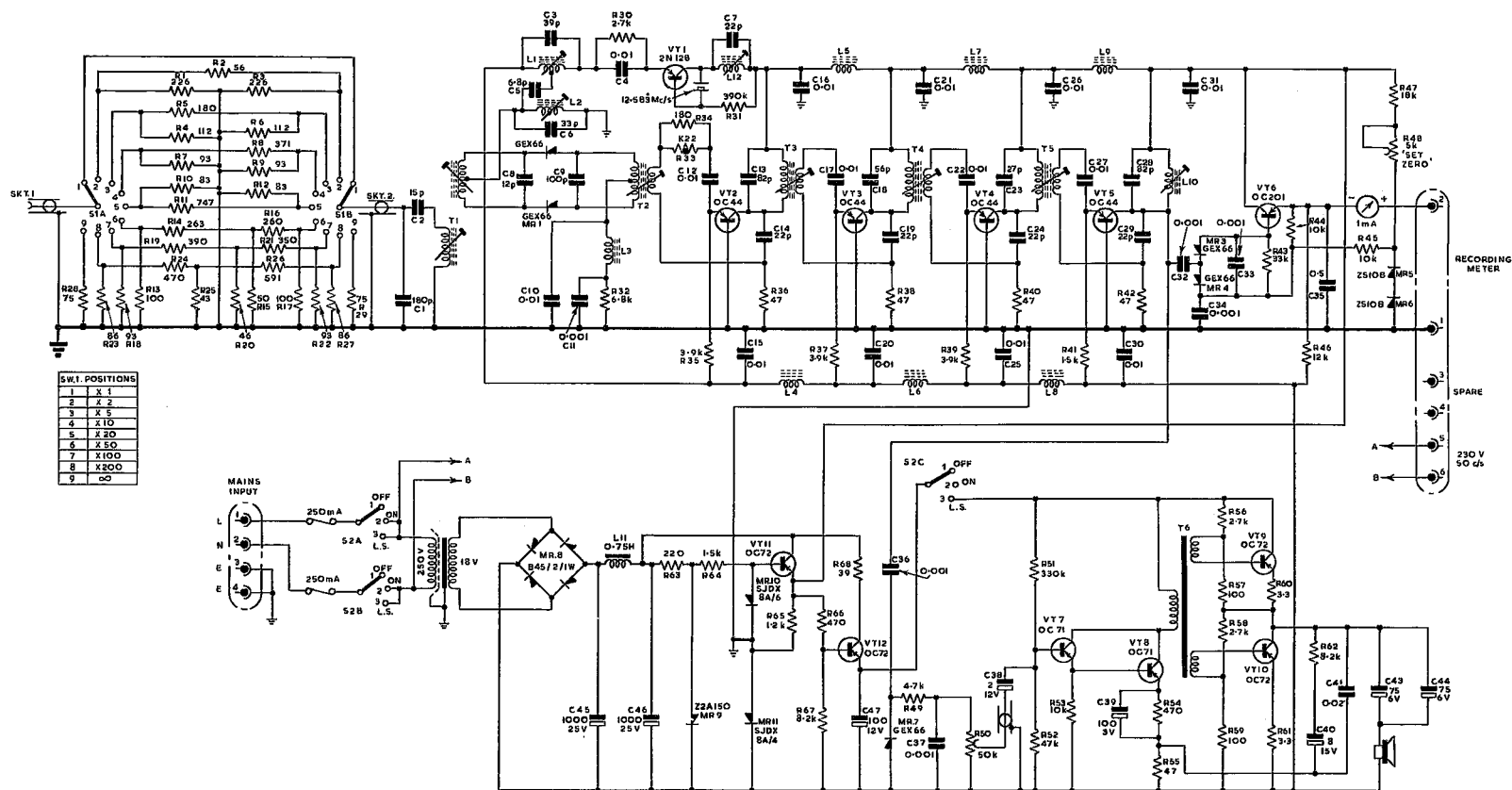


Fig. 2 - 41.5 Mc/s Field Strength Monitoring Receiver - Circuit Diagram

use of large emitter resistors R35, etc., supplied from a constant potential. The transformer ratios are arranged so that the reflected input conductance is large compared with the previous stage output conductance. This reduces the available stage gain but the gain becomes almost independent of changes of impedance with temperature (see Appendix). The input impedance of the amplifier, however, rises with temperature and would give a fall of gain if it was not compensated by the thermistor network R33, R34 in series with the input. This network also compensates for any small residual gain changes due to temperature in the rest of the receiver. The final i.f. amplifier VT5 directly feeds the audio detector MR7 and the voltage doubling meter detector MR3, MR4. The pass band characteristics of the i.f. circuits are improved by staggered tuning, T5 being tuned to $+40\text{ kc/s}$ and all the others to -46 kc/s relative to the nominal i.f. of 3.75 Mc/s .

3.3. Meter Amplifier

Since it was a requirement that one side of the recorder should be at earth potential a grounded collector amplifier VT6 is used with the output between emitter and earth. The stage has a gain of two as the detector circuit is biased to half the output voltage by a potential divider R44, R45 which thus provides considerable negative feedback. A small bleed current is taken by R46 to maintain the stage gain at zero output. Since a silicon transistor VT6 is used, leakage current is small and is partially compensated by the leakage of the diodes MR5, MR6 which are used to compensate for the change with temperature of base to emitter potential of the transistor VT6. A small pre-set potentiometer R48 is provided for adjusting the zero of the meters by varying the standing current through the compensating diodes MR5, MR6. A capacitor C35 across the meters reduces the effects of audio modulation on the output.

3.4. Audio Amplifier

The audio detector MR7 feeds the volume control R50 at the input to the audio amplifier. This amplifier has a high input impedance so as to reduce to negligible proportions any effects of the position of the volume control R50 on the detector loading and hence on the i.f. gain.

The first stage of the audio amplifier consists of a pair of transistors VT7, VT8 connected in the "Darlington Compound Connection"¹ and used as a grounded emitter stage to feed a Class B single-ended push-pull output stage VT9, VT10. The output directly feeds the 15 ohm speech coil of the loudspeaker through an isolating capacitor C43, C44. The bias on the output stage is adjusted for minimum audio distortion. Negative feedback is applied from the output to the emitter of the first stage via the resistor network R62, R55. A small capacitor C41, C42 across R62 gives some phase shift at high frequencies to improve the stability.

3.5. Power Supplies

The mains transformer supplies a bridge rectifier MR8 followed by a conventional L-C filter. Rough stabilisation is carried out by a Zener diode MR9 and final stabilisation by two series Zener diodes MR10, MR11 with the junction between the two diodes earthed. Emitter followers VT11 and VT12 provide low impedance outputs for the receiver and audio amplifier respectively.

Separate emitter followers are used to reduce any audio modulation of the supply potentials to the receiver and restrict transistor dissipations in the audio amplifier.

The stabilisation of the supplies allows the input voltage to be varied between 180 and 260 V for a gain change of less than ± 0.02 dB.

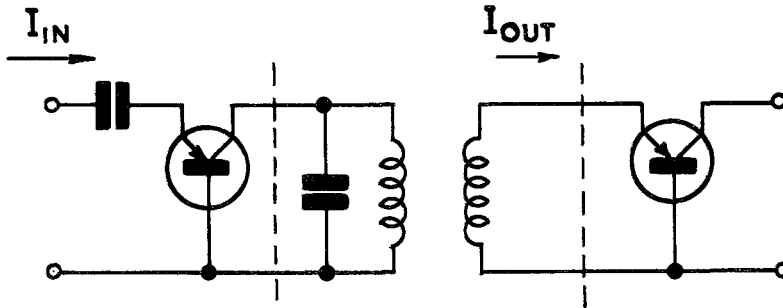
4. REFERENCE

1. Shea, R.F., "Transistor Circuit Engineering", J. Wiley and Sons, New York; Chapman and Hall, London, 1957.

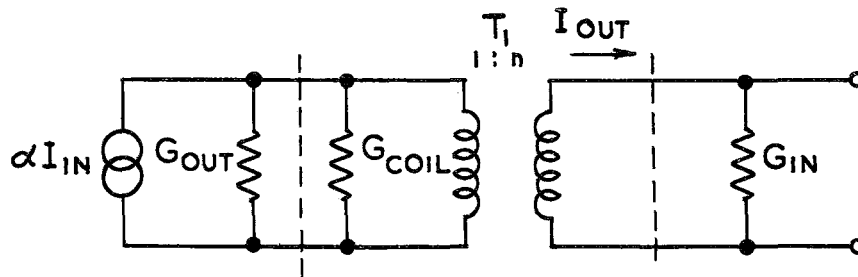
APPENDIX

Calculation of Stage Gain

The simplified circuit of an i.f. stage with d.c. connections omitted is as follows:



At resonance this is equivalent to



- where α = grounded base current gain of transistor
 I_{in} = input current of stage
 I_{out} = input current of next stage
 G_{out} = output conductance of transistor
 T_1 = an ideal transformer of 1:n turns ratio
 G_{coil} = coil loss parallel conductance
 G_{in} = input conductance of following transistor stage

$$I_{out} = \alpha I_{in} \left[\frac{n^2 G_{in}}{n^2 G_{in} + G_{coil} + G_{out}} \right]^{\frac{1}{n}}$$

$$\text{The stage gain (current)} \frac{I_{out}}{I_{in}} = \frac{\alpha}{n} \left[1 - \frac{G_{coil} + G_{out}}{n^2 G_{in} + G_{coil} + G_{out}} \right]$$

For an OC44 transistor at 3.75 Mc/s.

α is approximately 0.98 and will fall slightly (about 1%) with rise in temperature due to a fall in cut-off frequency with temperature.

n is fixed at $\frac{1}{8}$.

G_{in} falls 10% with temperature, mainly due to changes in α and is approximately 6 mmhos at 20°C.

G_{coil} is constant and is approximately 12 μ mhos.

G_{out} rises with temperature by about 20% between 20°C and 45°C and is approximately 10 μ mhos at 20°C.

Substitution in the above equation gives

$$\text{change of gain} = -0.25 \text{ dB from } 20^\circ\text{C to } 45^\circ\text{C}.$$

This closely agrees with the measured gain changes per stage.